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XF WS-A 606 1-12 (1970)
U.S. Fish Wildl. Serv.
Spec. Sci. Rep. Fish.

Annotated References on the Pacific Saury, Cololabis saira

SPECIAL SCIENTIFIC REPORT–FISHERIES No. 606

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

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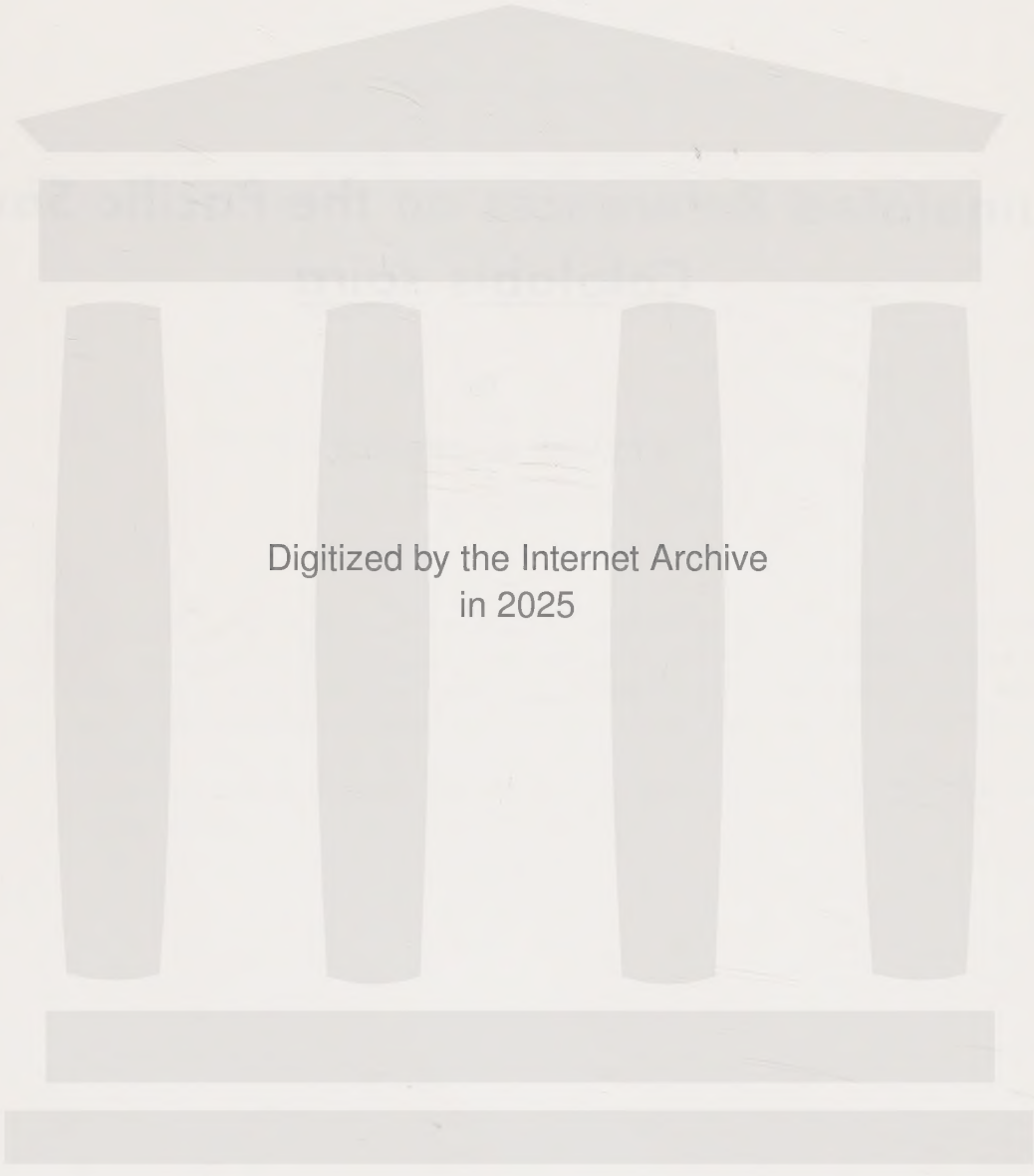
Annotated References on the Pacific Saury, Cololabis saira

By

STEVEN E. HUGHES

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 606

Washington, D.C.
June 1970



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Annotated References on the Pacific Saury, Cololabis saira

By

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ABSTRACT

The pertinent literature on the saury is reviewed, because of the recent interest in developing a fishery for this species along the west coast of the United States. Over three-fourths of the 72 references concern Japanese or Soviet reports on their saury stocks and fishing industries.

The annotations briefly describe the nature of the research and summarize the important results or conclusions.

A subject-author index is provided.

INTRODUCTION

Although the Pacific saury is not harvested commercially by United States fishermen, it is caught in considerable quantities by Soviet and Japanese fishermen in the western Pacific. Consequently, the Soviet and Japanese literature on saury is fairly extensive. Little research on saury has been carried out by U.S. scientists; however, interest in the possibility of developing a fishery in the eastern Pacific has grown rapidly in recent years.

I have prepared this report on foreign and domestic saury studies because of the growing U.S. interest in saury. Because present interest is concerned primarily in developing a saury fishery, emphasis has been given to the following subjects: (1) methods of harvesting and detecting saury; (2) the influence of environment such as temperature on saury distribution and behavior; and (3) assessment of stocks.

Because of extensive changes in the saury fishing industry after World War II, and the lack of biological studies prior to that time, most of the literature before 1950 was not included. Some of the 1968-69 literature has not been included because of the translation lag time. Most of the Japanese articles on saury are in the Bulletin of Tohoku Regional Fisheries Research Laboratory. Other foreign information, particularly Soviet articles, has been obtained mainly from Fishery and Oceanography Translations, 1964-65, and Foreign Fishery Translations, 1967 to February 1969. These two translation sources, prepared by BCF (Bureau of Commercial Fisheries), Washington, D.C. review numerous foreign articles on the fisheries.

A total of 72 references were compiled of which over three-fourths were from Soviet or Japanese journals.

The annotations are intended to (1) briefly describe the nature of the research because titles and particularly translated titles may be misleading and (2) summarize important results or conclusions.

The references are listed alphabetically by author and are cross-referenced in a subject index.

The titles of Soviet articles are given in transliterated form and English, whereas Japanese titles are only in English. Many of the Japanese articles with extensive summaries have not been translated. Annotations compiled from summaries are so indicated. All Soviet articles have been translated, and translations are available as indicated.

ACKNOWLEDGMENTS

Michael S. Inoue, Associate Professor, Department of Mechanical and Industrial Engineering, Oregon State University, who was under contract by BCF to travel to Japan and survey the Japanese saury fishing industry, helped compile the Japanese literature. Osamu Kibesaki (Tokai Regional Fisheries Research Laboratory, Tokyo) helped obtain and sent information from Japan.

SAURY BIBLIOGRAPHY

AHLSTROM, ELBERT H.

1968. An evaluation of the fishery resources available to California fishermen. In De Witt Gilbert (editor), The future of the fishing industry of the United States, pp. 65-80. Univ. Wash. Publ. Fish., New Ser. 4.

The size, embryonic development, and planktonic nature of saury eggs are discussed and compared with the eggs of other pelagic fish. Using only the egg data, the author estimates the adult saury population in the eastern North Pacific at 450,000 English tons;[1] however, counts of saury under lights at night indicate a much larger population. He mentions that saury are important to Russian and Japanese fishermen in the western North Pacific and that the Russians have evaluated the saury population in waters adjacent to Oregon and California.

AHLSTROM, ELBERT H., and HAROLD D. CASEY.

1956. Saury distribution and abundance, Pacific coast, 1950-55. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 190, 69 pp.

This paper is a data report on a 6-year study on the relative abundance and location of saury eggs and saury within the Pacific coast area covered by the California Cooperative Fishery Investigations. Saury eggs were collected by plankton nets or removed from floating objects. Small, medium, and large saury were counted under lights at night and sampled by dip net.

AIZAWA, YUKIO.

1963. The behaviour and reaction to fishing lamps in saury shoals. Bull. Tohoku Reg. Fish. Res. Lab. 23: 85-92. (In Japanese with English summary.)

Fishermen divide schools of saury into actively gathering schools, those that concentrate rapidly under alluring lights, and feebly gathering schools, those which respond less positively to alluring lights. The percentage of the former decreases as the fishing season progresses. Owing to the north to south migration during the fishing season, more actively gathering schools were noted in northern waters than in southern waters. The author classifies schools of saury attracted to light into five behavioral groups: (1) individuals recognizable, swimming near the surface; (2) individuals unrecognizable, swimming in comparatively deep layers; (3) schools with jumping members; (4) schools swirling near the surface; and (5) schools swimming in deep layers.

1967. Studies on the number of fin rays of the saury the differences among the modal groups in body length frequency and among the fish schools. Bull. Tohoku Reg. Fish. Res. Lab. 27: 11-20. (In Japanese with English summary.)

Previous studies indicated that saury migrating to the Northeastern Sea of Japan consist of two subpopulations, large and small fish in one group and medium-sized fish in the other.

The numbers of dorsal and anal fin rays were tabulated for the two groups from 1962 to 1965. The average number of dorsal fin rays was 10.56 to 11.38 in the large fish, 10.43 to 11.28 in the small fish, and 10.33 to 11.00 in the medium-sized fish. Saury migrating offshore had a higher average number of dorsal fin rays than inshore fish.

Reviewer's note: The author did not confirm or deny the subpopulation theory.

ANDREEV, N. N.

1962. Stick-held dip net for saury fishing. In his Spravochnik po orudiyam lova, setesnastnym materialam i promyslovomu snaryazheniyu (Handbook of fishing gear and its rigging). Pishchepromizdat, Moscow. (Translation pp. 418-420. Complete translation available at Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, TT 66-51046.)

Four diagrams are presented showing (1) a typical stick-held dip net and its rigging, (2) a tailoring system for making the net, (3) the deck arrangement of a saury vessel, and (4) a saury net being hauled aboard ship.

Net twine sizes, selvages, hanging coefficient, and auxiliary apparatus of a saury net are briefly discussed.

APLIN, J. A.

1939. The occurrence of sauries in southern California. Calif. Fish Game 25: 343-344.

An estimated 100 English tons of saury were reported south of Anacapa Island, Calif., on August 28, 1939. Such concentrations of this species in the California area are believed not common.

Behavioral patterns of saury in California waters are briefly discussed.

[1] All tonnage figures are metric unless specified as English.

AYUSHIN, B. N., O. P. KODOLOVA, and YU. V. NOVIKOV.

1967. Opyt uluchsheniya uslovii vosproizvodstva Tikhookeanskogo sairy (Experience in improving reproduction conditions of the Pacific saury). Ryb. Khoz. 43(5): 10-11. (Translation by Fisheries Research Board of Canada, Biological Station, Nanaimo, British Columbia, Translation Ser. 835.)

Optimum annual recruitment of young saury to the adult stock is reported as very critical in Japanese and Soviet waters. Investigators collected samples of floating seaweed in areas where saury were spawning and concluded that a shortage of such floating debris, to which saury eggs attach during the incubation period, undoubtedly reduced survival. Straw was scattered on the surface of the water, and as many as 8,000 eggs had attached to 500 g. of straw in a 24-hour period. Straw scattered in spawning areas may greatly increase spawning success.

CHAPMAN, WILBERT McLEOD.

1943. The osteology of the Pacific saury, Cololabis saira. Copeia 1943: 171-182.

The osteology and gross visceral anatomy of the Pacific saury are described from an examintaion of eight specimens from the Oregon, Washington, and British Columbia area. The phylogeny of Pacific saury and related species is also discussed.

CLEMENS, W. A., and G. V. WILBY.

1961. Fishes of the Pacific coast of Canada. Fish. Res. Bd. Can., Bull. 68, 2d ed., 443 pp.

A morphological description of Cololabis saira is presented. The role of saury eggs, larvae, and adults in the food chain is briefly discussed. The authors consider saury an excellent food fish and believe it may become commercially important to the west coast of the United States as it is now in Japan.

COMMERCIAL FISHERIES REVIEW.

1964. Japan. Saury fishery production and export trends late November 1963. Its vol. 26(2): 75.

Saury fishing in Japan picked up sharply in mid-November after a slow early season. During late November, 4,000 to 5,000 tons per day were being landed, and the price dropped from $103 to $50 a ton. Prices then tended to stabilize at $71 to $78 a ton.

The Japan Saury Sales Company was reported to have sold Egypt 90,000 cases of canned saury in December 1963 at $6.53 and $6.54 per case.

1965a. U.S.S.R. Electrical fishing with lights and pumps. Its vol. 27(1): 93-94.

The Soviets are developing a new method of fishing saury commercially. After the alluring lights have attracted the fish into the vicinity of the pump, a direct current electrical field is produced in the water. The fish are attracted to the suction pump, which serves as the anode, and pumped directly aboard the ship. One medium trawler took over 50 tons of saury in 12 days, 20 tons in 1 night.

1965b. Japan. Seasonal saury fishing disappointing. Its vol. 27(3): 81.

The 1964 Japanese saury landings through November 30 were 206,600 tons, 110,600 tons below the saury landings for the same period in 1963. During the late season the price of saury paid to the fishermen rose from about 4 cents to 8 cents a pound.

1965c. Japan. Saury fishery trends. Its vol. 27(3): 81.

In 1964 a proportionately larger than usual amount of the Japanese saury catch was frozen as bait because of a 200-percent increase in the price of bait saury in 1 year. As of December 15, 1964, the total Japanese saury catch (209,600 tons) was down about 40 percent from the previous year.

EBERHARDT, ROBERT L.

1954. Observations on the saury (Cololabis saira) seen near the California coast during 1950-52. Calif. Fish Game 40: 39-46.

Observations were made on the occurrence and behavior of saury along the coasts of California and Baja California. Saury were found throughout the study area, but commercial-sized fish were most abundant in the Santa Barbara Channel area during the fall and winter. Tables show the length-frequency information taken from various locations during the 3-year study.

FILIMONOVA, K. V.

1965. Ob effektivnosti promysla i obrabotki sairy v sisteme rybnoi promyshlennosti Sakhalina (On the effectiveness of fishing and processing the saury in the system of the Sakhalin fishing industry). Ryb. Khoz. 41(2): 81-82.(Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

The author feels that a Soviet saury fishing industry in their Far Eastern Pacific fishing grounds would be profitable. Specific saury products are discussed in terms of quality and economic feasibility. Limited catch information and types of fishing vessels used in the fishery are discussed (SRTR side trawlers are considered most efficient). During 1965, inadequate receiving systems, high processing costs, and extensive search time were slowing the expansion of the Soviet saury fishing industry.

FISHING NEWS INTERNATIONAL.

1968. Japan hopes new method will boost saury catch. Its vol. 7(11): 76 and 78.

A general method of attracting and catching fish schools is discussed, diagrammed, and compared with the new steps in the procedure. The development of the stick-held dip net, the decline of the Japanes saury catch during 1962-67, and the saury resource off Oregon and California are briefly discussed.

FUKUSHIMA, SHIN-ICHI.

1956. On the size-composition of the Pacific saury, Cololabis saira, caught in the

FUKUSHIMA, SHIN-ICHI--Con.

North-eastern Sea area of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 7: 12-36. (In Japanese with English summary.)

The size composition of the Pacific saury during its southward migration in the Northeastern Sea area of Japan during the fishing season (September to December) was studied. Length-frequency data from commercial catch samples showed that size vary considerably from year to year and between different fishing areas in one season. The author concluded that complex migration patterns persist and are probably regulated largely by prevailing oceanographic conditions.

1958. Relation between the fishing of the Pacific saury and the oceanographical conditions in the Northeastern Sea area along the Pacific coast of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 12: 1-27. (In Japanese with English summary.)

Relations between saury catches and oceanographic conditions were reported for 1949-57. The following conclusions were drawn: (1) catches were made in waters between 7° and 24° C.; (2) maximum catches were taken in waters between 14° and 18° C.; and (3) high water temperatures in the summer, adjacent to the Sanriku District, resulted in good fishing, but low water temperatures in the summer in this area resulted in poor fishing. Three water types and the resulting fishing conditions are discussed.

1962. On the relation between the pattern of the Kuroshio Current in spring and summer and the saury fishing conditions in fall. Bull. Tohoku Reg. Fish. Res. Lab. 21: 21-37. (In Japanese with English summary.)

The author describes five different oceanographic conditions that have occurred during the spring and summer south of Cape Shionomisaki, Japan, between 1951 and 1961. Using relation between these oceanographic conditions and the catch records, he can predict the saury catch during the autumn as very good, good, or poor.

FUKUSHIMA, SHIN-ICHI, and AKIRA NAGANUMA.

1956. On the thickness-coefficient of the saury, Cololabis saira. Bull. Tohoku Reg. Fish. Res. Lab. 7: 37-53. (In Japanese with English summary.)

The thickness coefficient ($f = 1{,}000w/l^3$ where f is the thickness coefficient, w is the body weight, and l is the body length) is greatest early in the fishing season and decreases as the season progresses. During the seasonal migration, the thickness coefficient decreases as the saury move north to south. There is a negative correlation between degree of sexual maturity and the thickness coefficient so that the thickness coefficient is smallest just before spawning. During 1951-54, the condition coefficient of small, medium, and large saury was compared during the migration cycle.

HATANAKA, MASAYOSHI.

1956a. Biological studies on the population of the saury, Cololabis saira (Brevoort). Part I Reproduction and growth. Tohoku J. Agr. Res. 6: 227-269.

This paper is a comprehensive report on reproduction and growth of the Pacific saury that inhabit the waters surrounding the Japanese Archipelago. The topics discussed in detail are: maturity and spawning, distribution of eggs and larvae, larval development, age determination, growth process, and condition factor.

Reviewer's note: The reported theories on age of saury are now believed incorrect.

1956b. Biological studies on the population of the saury, Cololabis saira (Brevoort). Part 2 Habits and migrations. Tohoku J. Agr. Res. 6: 313-340.

Behavioral and migrational patterns are presented and correlated with fluctuations in the Japanese saury catches. The following topics are discussed in detail: feeding habits and biological environments, migrations, and biological features of the commercially caught saury. Prevailing oceanographical conditions that affect migration patterns are believed primarily responsible for the large fluctuations in catch rates.

HOTTA, HIDEYUKI.

1958. On the growth of the young saury, Cololabis saira in the rearing experiment. Bull. Tohoku Reg. Fish. Res. Lab. 11: 47-64. (In Japanese with English summary.)

The digestive system of the saury is composed of a straight intestine and no stomach. The maximum food consumption of a young saury at one feeding is 13 percent of the body weight. The relation of fullness to body weight is given by the formula $Sw = 0.128\ W^{0.979}$ where Sw is the food weight in grams and W is the body weight in grams. At water temperatures between 15° and 21° C., a 12-cm. saury requires 9 to 10 hours to digest completely the contents in its intestines. A 6-cm. saury will grow to 20 cm. within 6 months. The length-weight relation of commercial-sized saury is $W = 0.000916\ L^{3.468}$ where W is weight in grams and L is length in centimeters.

1960. On the analysis of the population of the saury (Cololabis saira) based on the scale and the otolith characters, and their growth. Bull. Tohoku Reg. Fish. Res. Lab. 16: 41-64. (In Japanese with English summary.)

Studies on the body weight, body length, scales, and otoliths of commercial saury revealed that the population is composed of two subpopulations, spring- and fall-spawning saury. Both groups are made up of two sizes and two ages. The spring-spawners are composed of giant saury (modal weight of 155 g. and modal length of 32-33 cm.), and medium-size saury (85-95 g. and 27-28 cm.). The fall spawners are composed of large fish (135 g., 30 cm.) and small fish (45 g., 21-24 cm.). Giant saury are 2-1/2 years old; large saury, 2 years old; medium saury, 1-1/2 years old; and small saury, 1 year old. Differences in the scales and otoliths of the spring- and fall-born saury are also discussed.

1962. The parasitism of saury (Cololabis saira) infected with parasitic copepoda, Caligus macarovi Gussev, during fishing season in 1961. Bull. Tohoku Reg. Fish.

HOTTA, HIDEYUKI--Con.

Res. Lab. 21: 50-56. (In Japanese with English summary.)

Caligus macarovi attacks both the epidermis and the mucosa but never becomes imbeded in the muscular tissue. Saury with scars have a lower condition factor than saury without scars. The percentage of infected saury increased during the late summer and fall as the populations moved from the northern feeding grounds to the southern spawning grounds.

1963. Fluctuation in the abundance of saury on the Northeastern Sea of Japan (III). Bull. Tohoku Reg. Fish. Res. Lab. 23: 73-84. (In Japanese with English summary.)

North and south migration patterns of saury are discussed as they relate to the oceanographic conditions in the sea off the Tohoku region of Japan. The so-called spring-spawning saury generally occupy coastal waters during the early fall, and the so-called fall-spawning saury occupy offshore waters during the fall. Saury generally inhabit waters of 10° to 20° C.

1964a. Fluctuation in the abundance of saury on the Northeastern Sea area of Japan (IV). Bull. Tohoku Reg. Fish. Res. Lab. 24: 48-64. (In Japanese with English summary.)

It has been previously confirmed that two populations of saury exist in commercially fished areas during the fall. Possible correlations between a regular saury population cycle and the fluctuation of fishing conditions between 1929 and 1963 are discussed. The author concluded that a stable cyclic population pattern results in good fishing; however, the migratory pattern may be altered from year to year by oceanographic variations.

1964b. Fluctuation in the abundance of saury on the Northeastern Sea of Japan (V). Bull. Tohoku Reg. Fish. Res. Lab. 24: 65-72. (In Japanese with English summary.)

The relation between the population density and the growth of large and medium-sized saury is discussed and correlated mathematically. The author suggested that the population of medium-sized fish is decreasing while the population of large-sized fish is increasing. The total standing stock of saury is composed of two separate breeding populations, which, in this article, are referred to as medium and large fish.

1967. Fluctuation in the abundance of saury on the Northeastern Sea of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 27: 1-10. (In Japanese with English summary.)

Japanese saury landings for each 10-day period in September to December were compared during 1953-66. Landings increased rapidly during mid-September, reached one or more peaks between the last week of September and late October, decreased slowly until early December, and then dropped rapidly. The fishing peak during each 10-day period occurred during the new moon.

HOTTA, HIDEYUKI, and SIN-ICHI FUKUSHIMA.

1963. Fluctuation in the abundance of saury on the Northeastern Sea of Japan (II). Bull. Tohoku Reg. Fish. Res. Lab. 23: 61-72. (In Japanese with English summary.)

The spawning grounds of saury and the affect of temperature on developing embryos are discussed. The authors believe that saury spawn offshore in the fall, whereas middle-sized fish spawn among coastal seaweed in the spring. The time of hatching was 8 days at 25° C. to 33 days at 10° C. The biological zero temperature for hatching was calculated to be 5.5° C. Temperatures of 14° to 20° C. were considered optimal for the development of saury eggs.

HOTTA, HIDEYUKI, and KAZUKO ODATE.

1956. The food and feeding habits of the saury, Cololabis saira. Bull. Tohoku Reg. Fish. Res. Lab. 7: 60-69. (In Japanese with English summary.)

Food and feeding habits were investigated throughout 1951-55. The contents of about 1,500 digestive tracts indicated that crustaceans were the primary food source and Sagittoidea the secondary source. After the fish reaches a length of 60 mm., the type of food eaten does not change. The feeding rate (food weight/body weight x 100) of small saury is usually higher than that of adults. Saury feed heaviest during May to July and October to November. The authors also believe that saury feed heavily during the morning and very little at night.

HUBBS, CARL L., and ROBERT L. WISNER.

1953. Food of marlin in 1951 off San Diego, California. Calif. Fish. Game 39: 127-131.

The stomach contents of 32 marlin caught near San Diego in late August and throughout October were analyzed. Pacific saury constituted about 75 percent of the diet, both in numbers and volume. The next most abundant food was anchovy, which constituted about 20 percent of the diet by number and 12 percent by volume.

INOUE, MAKOTO, and KAICHIRO WATANABE.

1958. The fishing power of saury blanket net (Bouke-Ami) fishery. Bull. Jap. Soc. Sci. Fish. 23: 745-748. (Translation by Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, U.S. Department of the Interior.)

The authors reported how the fishing power of the saury blanket net (stick-held dip net) varies with different-sized vessels, the size of the net and auxiliary equipment (numbers of alluring lights, light color and intensity). They concluded that net size and the number of attraction lamps have no relation with the fishing power of the Bouke-Ami* and that the average catch of a 10- to 29-ton vessel is about 60 percent of a vessel 30 tons or larger. Considerable information on Japanese saury vessels, crew size, and fishing equipment is presented.

*Reviewer's note: This conclusion contradicts several other studies.

KIMURA, KINOSUKE.

1956a. The standard length of the Pacific saury, Cololabis saira (Brevoort). Bull. Tohoku Reg. Fish. Res. Lab. 7: 1-11. (In Japanese with English summary.)

The author reported various Japanese methods of measuring the length of fish. The standard length adopted in Japan is the distance between the tip of the lower jaw and the posterior end of the muscular nob on the caudal base.

1956b. A theory of congregation and separation of fish by oceanographic condition. Report 1 referring to Pacific saury fishing of Tohoku Regional Sea in fall. Bull. Tohoku Reg. Fish. Res. Lab. 7: 103-145. (In Japanese with English summary.)

It was previously accepted that during the north to south saury migration, the larger fish precede the smaller ones. This study indicated that this generalization is not always true and that the southward migrating population may have either a bimodal or unimodal length composition depending on oceanographic conditions. The larger saury do begin the southward migration first; however, they will not penetrate a well-defined thermal gradient. As a result the medium-size saury often catch up and intermix with the large saury before the thermal gradient has weakened sufficiently so that southerly migration can proceed. Thus the timing of the southerly migration in the fishing grounds may be predicted by the presence or absence of the "shiozakai" (boundary waters between the warm Kuroshi Current and the colder Oyashio Current). This phenomenon also accounts for the abundance of large saury in the southerly fishing grounds and medium saury in the more northerly fishing grounds during years of unstable thermal gradient.

1956c. Drift-net fishery of Pacific saury of Japan in 1936-43. Tohoku Reg. Fish. Res. Lab. 7: 146-183. (In Japanese with English summary.)

Before 1948, the Japanese fished saury by drift nets (gill nets). Although gill netting was not nearly as efficient as the present method (Bouke-Ami or stick-held dip net), good catches were made and the basic saury migration patterns were established. Catch information is presented, and migration patterns described.

1956d. On the Pacific saury caught by the set-net. Bull. Tohoku Reg. Fish. Res. Lab. 7: 184-238. (In Japanese with English summary.)

Before 1948, set nets and the more popular drift net or free floating gill nets were used as commercial saury fishing gear. Although the catch by set nets was generally not high, basic migration routes of saury were established from catch information. General migration patterns are described.

1960. A population study on autumn Pacific saury (Cololabis saira) in the Northeastern Sea of Honshu, Japan. Bull. Tohoku Reg. Fish. Res. Lab. 14: 1-82. (In Japanese with English summary.)

Three main aspects of saury fishing are reported: (1) movements of saury within the Japanese fishing grounds; (2) factors concerning or affecting the fishing effort; and (3) a calculation of catch per unit of effort for the stick-held dip net. The catch per unit of effort dropped as the fishing season progressed. Movements of fish in the fishing grounds varied because of many factors such as differences in size composition, oceanographic conditions, and areas within fishing grounds.

KIMURA, KINOSUKE, SHIN-ICHI FUKUSHIMA, SHIGERU ODATE, and YUKIO AIZAWA.

1961. Main spawning season and ground of the Pacific saury migrating southward in Tohoku Kaiku. Bull. Tohoku Reg. Fish. Res. Lab. 19: 1-41. (In Japanese with English summary.)

Information presented in this report supports the Japanese theory on saury migration and age composition as it pertains to spawning. Considerable data on spring-spawning and fall-spawning saury and information on larval development and migration patterns are presented. The authors concluded that saury do not spawn until they reach 30 cm. long. Thus, saury that are less than 30 cm. long in the fall are probably spring-spawning fish.

KIMURA, KINOSUKE, HIDEYUKI HOTTA, SHIN-ICHI FUKUSHIMA, SHIGERU ODATE, AKIRA FUKUHARA, and MASAJI NAITO.

1958. Study of the Pacific saury spawning on the drifting seaweeds in the Sea of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 12: 28-45. (In Japanese with English summary.)

This study indicated that spawning saury concentrate into large schools along the border of the Japan Sea Front (an area of warm and cold waters) where large amounts of floating seaweed are common. After eggs are deposited, they adhere to seaweed until they hatch. Spawning takes place during the entire 24-hour period, with peak spawning activities at midnight, early morning, and midafternoon. Waters surrounding the seaweed heavily loaded with saury eggs harbor many species of larval and juvenile fish. Stomachs of Agrammus agrammus weighing 3 to 20 g. contained quantities of saury eggs equal to 10 percent of their body weight.

KIMURA, KINOSUKE, HIDEYUKI HOTTA, SHIGERU ODATE, AKIRA FUKUHARA, and MASAJI NAITO.

1956. Pacific saury in the adjacent seas of Tsugaru Strait. Bull. Tohoku Reg. Fish. Res. Lab. 7: 239-295. (In Japanese with English summary.)

The migration patterns of the Pacific saury in the commercially fished waters of Japan are presented in detail. General migration patterns varied annually and were regulated by movements of water masses and associated temperature fluctuations. Drift-bottle data were helpful in predicting migration routes in coastal waters.

KOBAYASHI, TAKASHI, MAKOTO WAKO, and MASAJI NAITO.

1968. Studies on the life of the Pacific saury, Cololabis saira (Brevoort). I. Aggregative characteristics of adult of the autumn-spawning population. Sci. Rep. Hokkaido Fish. Exp. Sta. 9: 1-45. (In Japanese with English summary and figures.)

KOBAYASHI, TAKASHI, MAKOTO WAKO, and MASAJI NAITO--Con.

This detailed study on the life history of the autumn-spawning saury population in the western Pacific is based on data for 1959-67. A hypothesis is presented on the yearly life cycle of the saury based upon sexual development, feeding habits, and migration patterns.

KOTOVA, L. I.

1958. O biologii razmnozheniya sairy v Yaponskom more (The biology of reproduction of the saury in the Sea of Japan). Ryb. Khoz. 34(10): 6-10. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Information on migration patterns, sexual development, spawning habits, and egg and larval development of the Pacific saury, resulting from Soviet investigations, is reported. Contrary to Japanese beliefs, this author found that saury do not spawn until they are 3 or 4 years old and that 5-year-old fish are common. Information regarding migration patterns has limited value because of the use of local geographical names. Sexual development during the year are classified in a six-step scale, which was not defined.

KUNDIUS, M.

1966a. O novykh raionakh lova sairy (New regions of Pacific saury fishery). Ryb. Khoz. 42(10): 16-19. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Soviet attempts to develop a commercial saury fishing industry in the northern Sea of Japan and the Okhotsk Sea are reported. The author found that, in September and early October, the rate of southward migration depends largely upon weather conditions. Cold northerly winds resulted in a rapid southward movement of fish, and very poor commercial catches. These areas might be fished in August.

1966b. O methodakh prognozirovaniya na promysle sairy (On forecasting methods in saury fishing). Ryb. Khoz. 42(11): 17. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Thermal stratification patterns are considered very important in saury fishing off the coasts of Russia and northern Japan. The author believed that southerly winds create strong thermal gradients at the current junctions, resulting in good fishing even on moonlight nights, whereas irregular or northerly winds result in poorly defined thermal gradients and less productive fishing.

LUBNY-GERTSYK, E. A.

1961. Pitanie molodi sairy (Cololabis saira) (Food of young saury (Cololabis saira)). Tr. Inst. Okeanol. 45: 279-283. (Translation 1969, pp. 285-289 in Oceanographic research by the "Vityaz" in the North Pacific under the I.G.Y. Program, available at Clearinghouse for Federal Science Technical Information, Springfield, Va. 22151, TT 68-50358.)

The stomach contents of larval and juvenile saury collected between October 1958 and March 1959 were analyzed qualitatively and quantitatively. Newly hatched larvae, 6 to 8 mm. long and planktonic in nature, are indiscriminate feeders. Small planktonic mollusks, copepods, Globigerinae, Tintinnidae, and sand were found in their stomachs. Large larvae are active swimmers and seemed to feed selectively on copepods. Juvenile saury feed mostly on Clausocalanus.

NAGAKURA, KATSUO.

1956. The variation of the fat content of saury, Cololabis saira, in the Northeastern Sea area of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 7: 54-59. (In Japanese with English summary.)

Seasonal variation of the fat content of saury was examined during 1953-55. All body oils were squeezed out or extracted with ethyl ether and weighed. The fat content was high from the beginning of the fishing season (August) through the middle of October. The fat content dropped rapidly toward the end of the season (presumably late November or early December).

NIKONOROV, I. V.

1965a. Vybor rezhima osveshcheniya pri love ryby na svet (Selecting an illumination regime during light fishing). Ryb. Khoz. 41(2): 48-50. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Techniques of operating various types of alluring light in the fisheries for saury, mackerel, sprat, anchovy, and skipjack are discussed. The following information pertaining to saury are reported: (1) saury are attracted into catchable schools by overhead lights but not by underwater lights, (2) saury do not make significant vertical migrations; however, they are found in the surface waters at night, (3) the amount of vertical migration tends to increase during the autumn, and (4) the reaction of saury to light may vary depending upon sexual development and feeding periods.

1965b. Vybor rezhima osveshcheniya pri love ryby na svet (Selection of illumination conditions when fishing with light). Ryb. Khoz. 41(3): 41-43. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

This is the second and concluding part of the paper by Nikonorov (1965a). The following pertinent conclusions on light fishing for saury are presented: (1) use many low-power lights rather than a few high-power lights, (2) do not use blue lights, (3) dim briefly or sweep slowly back and forth the lights to attract saury closer to the light source, and (4) use red lights during the final fishing stage.

NOVIKO, N. P., and E. I. CHERNYI.

1967. Perspektivy sovetskogo promysla v vostochnio chasti Tikhogo okeana (Soviet fishery prospects in the eastern Pacific Ocean). Ryb. Khoz. 43(3): 5-7. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Populations of several commercial species of fish off the west coast of the United States are discussed, and their value to the U.S.S.R. fishing industry summarized. The Pacific saury was considered the most important and valuable pelagic stock. Behavioral aspects of this stock are reportedly very similar to those near the Kuril Islands. The Soviet saury fishing fleet could fish this area with minor alterations and minimum preparations.

NOVIKOV, N. P., and YU. M. KULIKOV.

1966. Perspektivnyi raion promysla sairy (Prospective region for saury fishing). Ryb. Khoz. 42(7): 20-21. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Results of an extensive saury survey off the west coast of North America, lat. 40° to 54° N., are reported. The most dense concentrations of sexually mature adults were between lat. 42°18' and 44°22' N., during August, October, and November in water temperatures of 12.5° to 13.5° C. In October, commercial quantities of adults were found throughout an estimated 13,000-square-mile spawning area.

NOVIKOV, YU. V.

1960. Opredelenie vozrasta po cheshue i vozrastnoi sostav sairy [Cololabis saira (Brevoort)] v raione yuzhnykh Kuril'skikh ostrovov (Age determination from scales, and age composition of Pacific saury (Cololabis saira (Brevoort)) in the region of the south Kurile Islands). Izv. Tikhookean. Nauch.-issled. Inst. Ryb. Khoz. Okeanogr. 46: 233-241. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Scales were used to determine the ages of Pacific saury collected between August and November 1958 in the Kuril Island region. The following conclusions were drawn: (1) the annulus forms during the winter and coincides with growth retardation because of low food production; (2) scales show different growth characteristics indicating different origins; and (3) in the fall, southward migrating fish are primarily 3 and 4 years of age.

Reviewer's note: The Japanese believe that these fish are 1-1/2 and 2 years old.

1966. Vliyanie gidrologicheskikh uslovii na promyslovye zapasy sairy (Effect of oceanic conditions on the commercial reserves of saira). Ryb. Khoz. 42(1): 16-18. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

The Soviet and Japanese saury catches were quite low during the 1964 fishing season. The low catches were attributed to unusually cold waters and unstable thermal gradients in the fishing regions. The southward migration of saury through the fishing grounds was farther off shore and 15 to 20 days later than usual. Once saury entered the fishing grounds they passed southward quickly, thus the fishing season was short.

NOVIKOV, YU. V., and L. V. KLYUEV.

1958. Raiony promyslovykh skoplenii i lov sairy v Tikhom okeane (Saury concentration areas and fisheries in the Pacific Ocean). Ryb. Khoz. 34(5): 8-13. (Translation 1960, available at Clearinghouse for Federal Science Technical Information, Springfield, Va. 22151, OTS 60-21100, 9 pp.)

The authors report the locations, school sizes, and oceanographic conditions in which saury were found off the coast of U.S.S.R. and northern Japan. The use of the stick-held dip net with alluring lights is described in detail. Diagrams are provided. The Soviets consider catches of 3 to 5 centners (1 centner = 0.1 metric ton) per haul as average, 6 to 10 centners per haul as good, and catches over 10 centners as excellent. For 1 night's fishing, catch of 30 centners is average; 100 centners, good; and above 100 centners, excellent.

ODATE, SHIGERU.

1956a. On the distribution of larvae and young of the saury, Cololabis saira, and the condition of maturity of the gonad of the spawning fish in the neighbourhood of Izu Island and the North-eastern Sea area of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 7: 70-102. (In Japanese with English summary.)

About 12,500 gonads were measured and classified as "Immature A" (weight of gonad 0.1-0.3 g.), "Immature B" (0.6-0.8 g.), "Maturing" (1.0-3.0 g. -- small eggs visible through the ovarian sac), and "Matured" (over 3.0 g. -- ovary large and presumed mature). Variation in testes weight was almost the same as the variation in ovarian weight. During the fall and winter, the weights of gonads varied greatly between individuals and varied slightly between size groups. Information on the temporal and spatial distribution of larvae is also presented.

1956b. The vertebral number of the saury, Cololabis saira (Brevoort). Bull. Tohoku Reg. Fish. Res. Lab. 8: 1-14. (In Japanese with English summary.)

Vertebrae were counted on 1,700 larval saury from the Tohoku, Izu, and Circum-Kyushu regions and 6,300 adults from the Tohoku region. Larval saury from the northern region had higher mean number of vertebrae than those from the southern regions (69.9 in the Tohoku region, 64.6 in the Izu region, and 64.5 in the Circum-Kyushu region). The variation in numbers of vertebrae has been attributed to differences in water temperature in the three areas. Although he noted that the mean number of

vertebrae varied between larval size groups in one area, the author suggested that vertebral numbers may serve as indigenous tag.

1958. Morphological studies of the saury, Cololabis saira (Brevoort). Tohoku Reg. Fish. Res. Lab. 11: 38-46. (In Japanese with English summary.)

Body length, head length, body height, number of finlets, number of rays in dorsal and anal fins, and gill raker dimensions were obtained from larvae, young, and adults captured in the Izu Sea area and the Northeastern Sea region of Japan. The number of soft rays and finlets became constant when the larvae reached 2 cm. in body length. Formulas that describe the growth of larval and postlarval stages are presented.

1962a. Distribution of larvae of the saury, Cololabis saira (Brevoort), in the surrounding Sea of Japan. Bull. Tohoku Reg. Fish. Res. Lab. 20: 67-93. (In Japanese with English summary.)

The larvae and young fish collected with a surface net during a 13-year study were divided into four groups based on morphological changes: (1) postlarval group I -- under 10 mm. in body length, including prelarvae and smaller postlarvae, (2) postlarval group II -- 10 to 25 mm., (3) juvenescent group -- 25 to 50 mm., and (4) young fish over 50 mm. Postlarval fish were collected primarily during fall and spring, indicating that there are two main spawning seasons each year. Areas having concentrations of larvae are reported.

1962b. Analysis of population of the saury, basing on the vertebral charactor. Part I. On the number of vertebrae of the saury caught in the fall fishing season. Bull. Tohoku Reg. Fish. Res. Lab. 21: 38-49. (In Japanese with English summary.)

Vertebral counts were made on 28,280 saury collected from the Northeastern Sea region off Japan during 1956-61. The average number of vertebrae for medium-sized fish (25-28 cm.) was 64.7 to 64.9, whereas that for large fish (30 cm.) was 65.0 to 65.3, suggesting population differences between the two groups. Significant variations in the vertebral counts between year classes of each group was attributed to variations in environmental conditions between years and spawning areas.

PARIN, N. V.

1960. Areal sairy (Cololabis saira Brev.--Scombresocidae, Pisces) i znachenie okeanograficheskikh faktorov dlya ee rasprostraneniya (The range of the saury (Cololabis saira Brev.--Scombresocidae, Pisces) and effects of oceanographic features on its distribution). Dokl. Akad. Nauk SSSR 130(3): 649-652. (Translation by Bureau of Commercial Fisheries Ichthyological Laboratory, U.S. Department of the Interior, Washington, D.C.)

The author reported that the California and Japanese saury are probably not separate species as previously believed. The distribution of saury is described as amphi-Pacific. Results of several Russian research cruises indicate that their distribution is limited only by water temperatures (spawning temperatures of 13°-20° C. and feeding temperatures of 9°-17° C.) and by the availability of food and spawning grounds. Information on the distribution, abundance, and size of saury in the Pacific Ocean, including waters off the American coast, is given for various times of the year.

POTAPOVA, G. A.

1965. Literatura po rybokhozyaistvennym issledovaniyam v severo-vos-tochnoi chasti Tikhogo okeana (Literature on fishery research in the northeast Pacific Ocean). Tr. Vses. Nauch.-issled. Inst. Morsk. Ryb. Khoz. Okeanogr. (Izv. TINRO 53): 58: 311-345. (Translation pp. 297-373 in "Soviet fisheries investigations in the northeast Pacific, Part IV," available at Clearinghouse for Federal Science Technical Information, Springfield, Va. 22151, TT 67-51206.)

The author compiled 1,065 references on Soviet fishing operations in the Pacific Ocean. The titles of several articles on saury are included.

RADOVICH, JOHN, and EARL D. GIBBS.

1954. The use of a blanket net in sampling fish populations. Calif. Fish Game 40: 353-365.

The operation of a blanket net is described, and its possible use as a standard sampling device for pelagic species discussed. The net caught Pacific saury at one fishing station near the coast of Baja California.

ROMANOV, N. S.

1959. Ukazatel' literatury po rybnomu khozyaistvu Dal'nego Vostoka za 1923-1956 gg (Annotated bibliography on Far Eastern aquatic fauna, flora, and fisheries). Izdatel'stvo Akademii Nauk SSSR, Moscow, 290 pp. (Translation available at Clearinghouse for Federal Science Technical Information, Springfield, Va. 22151, TT 64-11101.)

The author compiled and annotated 3,700 articles. The 2,931 articles on fishes and fisheries are believed to include much of the Soviet publications related to these fields that were published between 1923 and 1956. Very few of the 46 articles that deal with Pacific saury are detailed studies.

SCHULTZ, LEONARD P.

1940. The Pacific saury, Cololabis saira Brevoort from the North Pacific Ocean. Copeia 1940: 270.

Five young saury were collected in midocean between San Diego, California, and the Hawaiian Islands. The author believes that these records further substantiate a previous conclusion by Hubbs (1916) that the eastern and western Pacific saury are the same species and range throughout the North Pacific Ocean.

SHABANOV, A. N.

1966. Sovetskie issledovateli-osnovopolozhniki teorii lova ryby na svet (Soviet scientists-pioneers of the theory of fishing with light). Ryb. Khoz. 42(1): 41-44. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Specific aspects of saury fishing with lights are not reported in this paper; however, basic concepts related to fishing with lights are presented.

SIDEL'NIKOV, I. I.

1966. O ratsional'nom ispol'zovanii svetovogo oborudovaniya na sudakh, zanyatykh lovom sairy (The optimum use of lighting equipment on ships for Pacific-saury fishing). Tr. Vses. Nauch-issled. Inst. Morsk. Ryb. Khoz. Okeanogr. 61: 191-196. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Lighting techniques were tested, and their ability to attract saury evaluated. This study indicated that (1) alluring lamp standards should be placed 4 to 6 m. apart and the illumination rate should not exceed 200 to 300 lux near the ship, (2) the light beam should be angled 45° from the surface, and (3) fluorescent lamps attract fish more effectively and require less power than incandescent lamps.

SUISANSHA.

1966. The saury stick-held net fisheries. In Suisan Nenkan. (Yearbook of fisheries) Suisansha, Tokyo, pp. 212-221. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

Information on the 1964 Japanese saury catch is presented and compared with catches of previous years. Conditions that affected the total catch from 1960 to 1964 are discussed (fishing effort, thermal conditions, fish movements, and typhoons). Production values, catch rates by vessel size and the average catch per man on various-sized vessels are computed. The percentage distribution of the total catch to the major markets is presented for 1961-64.

UMEMOTO, SHIGERU.

1959. Amino acids in the meat extractives of Pacific saury (Colorabis saira Brevoort). Bull. Tohoku Reg. Fish. Res. Lab. 15: 86-88. (In Japanese with English summary.)

Amino acids in Pacific saury were separated and detected by the use of two dimensional paper chromatography. The following amino acids were detected: alanine, aspartic acid, glutamic acid, glycine, histidine isoleucine + leucine, phenylaline, proline, serine, taurine, threonine, tryptophane, tysosine, and valine.

YAMAMURA, YAROKURO, and SEIICHIRO MUTO.

1962. Studies on the "phototaxis" of the saury (I) In relation to the vitamin A of the eye and the other organs. Bull. Tohoku Reg. Fish. Res. Lab. 21: 57-62. (In Japanese with English summary.)

The percentage of sexually mature saury caught by the light-attraction stick-held dip net method is lower than that taken by drift gill nets. This study indicated that as saury become sexually mature, vitamin A is concentrated in the gonads at the expense of other organs, including the eyes. Apparently, lack of vitamin A in the eyes results in a reduced photopositive response to fish-alluring lights.

YUSA, TATSUO.

1960. Embryonic development of the saury Cololabis saira (Brevoort). Bull. Tohoku Reg. Fish. Res. Lab. 17: 1-14.

The complete embryonic development of the saury is presented in detail. The paper has 42 excellent photographs.

ZUSSER, S. G.

1967a. Biologicheskie issledovaniya sairy i ee promysel (Biological studies of the saury and its commercial fishing). Ryb. Khoz. 43(6): 81-82. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

This article has been translated into Russian from Japanese. Original work by Hotta (1964) was condensed by Zusser. A geographical overview of the three species of saury with emphasis on the Pacific saury is presented. The art of "hand fishing" for saury, which may be useful as a simple sampling technique, is described.

1967b. Biologicheskie issledovaniya sairy i ee promysel (Biological studies of saury and its commercial fishing (conclusion)). Ryb. Khoz. 43(7): 84-85. (Translation by Bureau of Commercial Fisheries Office of Foreign Fisheries, U.S. Department of the Interior, Washington, D.C.)

A brief history of Soviet saury fishing procedures, catches, fishing vessels, and forecasting methods is presented. Soviet investigators rely heavily on information on oceanographic conditions (particularly water temperatures and currents) to predict migration patterns and areas of fish concentrations. Studies are made annually to determine the recruitment rate of saury.

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[2] Most of the references under the respective subject categories pertain to the western stock of Pacific saury. For convenience, studies of the eastern stock of Pacific saury have also been listed at the end of the subject index.

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